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FOR: ANGULAR VELOCITY SENSOR AND MANUFACTURING METHOD THEREOF

VERIFICATION OF A TRANSLATION

Assistant Commissioner for Patents
Washington, D.C. 20231
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2. That I am knowledgeable in the English language and in the language of JP2004-061965, and I believe the attached English translation to be a true and complete translation of JP2004-061965.

3. The document for which the attached English translation is being submitted is a patent application on an invention entitled ANGULAR VELOCITY SENSOR AND MANUFACTURING METHOD THEREOF.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Date: July 31, 2009

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[NAME OF ARTICLE] Drawing 1
[NAME OF ARTICLE] Abstract 1
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[Name of the Document] Claims

[Claim 1]

An angular velocity sensor comprising a substrate shaped like a tuning fork having at least a pair of arms and a joint section for connecting these arms, and a laminated body laminating a barrier layer, a first adhesion layer, a lower electrode layer, an orientation control layer, a piezoelectric thin film, a second adhesion layer, and an upper electrode, sequentially on each one of the arms of the substrate, wherein the substrate is made of single crystal silicon, the barrier layer is mace of a silicon oxide film, the first adhesion layer is made of at least titanium, and the lower electrode layer is made of platinum containing at least titanium or titanium oxide.

[Claim 2]

The angular velocity sensor of claim 1, wherein the orientation control layer is made of an oxide derivative containing at least Pb and Ti.

[Claim 3]

The angular velocity sensor of claim 1, wherein the orientation control layer is made of PLMT.

[Claim 4]

The angular velocity sensor of claim 1, wherein the piezoelectric layer is a PZT layer.

[Claim 5]

A method of manufacturing an angular velocity sensor comprising a substrate shaped like a tuning fork having at least a pair of arms and a joint section for connecting these arms, and a laminated body laminating a barrier layer, a first adhesion layer, a lower electrode layer, an orientation control

layer, a piezoelectric thin film, a second adhesion layer, and an upper electrode, sequentially on each one of the arms of the substrate, wherein the surface of a substrate made of single crystal silicon is oxidized to form a barrier layer of a silicon oxide film, a first adhesion layer made of at least titanium is formed on the barrier layer by sputtering method, a lower electrode layer made of platinum containing at least titanium or titanium oxide is formed on the first adhesion layer by sputtering method, an orientation control layer is formed on the lower electrode layer by sputtering method, a piezoelectric thin film is formed on the orientation control layer by sputtering method, a second adhesion layer is formed on the piezoelectric thin film by sputtering method or vacuum deposition method, and an upper electrode layer is formed on the second adhesion layer by sputtering method or vacuum deposition method.

[Claim 6]

The method of manufacturing an angular velocity sensor of claim 5, wherein the barrier layer is formed by thermally oxidizing the surface of the substrate made of single crystal silicon.

[Claim 7]

The method of manufacturing an angular velocity sensor of claim 5, wherein the orientation control layer is made of an oxide derivative containing at least Pb and Ti.

[Claim 8]

The method of manufacturing an angular velocity sensor of claim 5, wherein the orientation control layer is made of PLMT.

[Claim 9]

The method of manufacturing an angular velocity sensor of claim 5, wherein the piezoelectric layer is a PZT layer.

[Name of the Document] Specification

[Title of the Invention] Angular velocity sensor and manufacturing method thereof

[Field of the Invention]

[0001]

The present invention relates to an angular velocity sensor having a thin film laminated structure and a method of manufacturing the same.

[Background Art]

[0002]

A conventional angular velocity sensor is described while referring to Fig. 3 and Fig.4. Fig. 3 is a perspective view of a conventional angular velocity sensor, and Fig. 4 is a schematic diagram showing its thin film laminated structure.

[0003]

Conventional angular velocity sensor 1 includes substrate 4 shaped like a tuning fork, having a pair of arms 2a, 2b extending in a specified direction (y-direction shown in Fig. 3), and joint section 3 for connecting this pair of arms 2a, 2b. This substrate 4 has laminated body 11 formed by laminating first adhesion layer 5, lower electrode layer 6, orientation control layer 7, piezoelectric thin film 8, second adhesion layer 9, and upper electrode layer 10 sequentially on each one of arms 2a, 2b as shown in Fig. 4. By applying alternating-current voltages of mutually reverse phases to each upper electrode layer 10 on each one of arms 2a, 2b, arms 2a, 2b are moved to right and left.

[0004]

At this time, substrate 4 is made of single crystal silicon (Si), first adhesion layer 5 is made of at least titanium, lower electrode layer 6 is made of platinum (Pt) containing at least Ti or TiOx, orientation control layer 7 is made of lanthanum-magnesium-added lead titanate (PLMT), and piezoelectric thin film 8 is made of lead zirconate titanate (Pb (Zr, Ti) O_3: PZT).

[0005]

Literature of prior art relating to the present invention includes, for example, patent document 1.

[Patent document 1] Japanese Patent Publication No. 3481235

[Disclosure of the Invention]

[Problems to be Solved by the Invention]

[0006]

By the background art, however, angular velocity sensor 1 cannot be reduced in size.

[0007]

That is, in the configuration of substrate 4/first adhesion layer 5 made of Si/Ti, the crystallinity of PZT is poor. Discussing this point in detail, Si and Ti react with each other at high temperature when forming laminated body 11. By this reaction, Si atoms degenerate by diffusing in Pt of lower electrode layer 6 and PZT in orientation control film 7 formed thereon and piezoelectric thin film 8 formed further thereon. When Si diffuses in PZT of piezoelectric thin film 8, adverse effects are given to the

crystallinity of PZT of piezoelectric thin film 8, which cannot be oriented by priority on crystal orientation (001) surface. Therefore, the piezoelectric characteristic of piezoelectric thin film 8 cannot be enhanced.

[0008]

As a result, piezoelectric thin film 8 of a large area is needed for enhancing the piezoelectric characteristic, and hence angular velocity sensor 1 cannot be reduced in size.

[0009]

It is hence an object of the present invention to reduce the size of angular velocity sensor 1 by enhancing the piezoelectric characteristic of piezoelectric thin film 8 provided in arms 2a, 2b of angular velocity sensor 1.

[Means to Solve the Problems]

[0010]

To achieve the object, in particular, the present invention provides an angular velocity sensor of which substrate is made of single crystal silicon and barrier layer is made of a silicon oxide film, first adhesion layer is made of at least titanium, and lower electrode layer is made of platinum containing at least titanium or titanium oxide. As a result, the angular velocity sensor is reduced in size.

[Advantage of the Invention]

[0011]

According to the present invention, by forming a barrier layer of SiO_2 between the substrate and the first adhesion layer, Si atoms on the substrate are prevented from diffusing into the piezoelectric thin film, and the crystallinity of the piezoelectric element can be enhanced, and as a result,

the piezoelectric characteristic of the piezoelectric thin film can be enhanced, and the angular velocity sensor can be reduced in size.

[0012]

Further, the configuration of the angular velocity sensor of the present invention can enhance the adhesiveness of the laminated body. That is, the substrate/barrier layer/first adhesion layer are formed in $Si/SiO_2/Ti$, and SiO_2 and Ti are high in reducing properties, and the bonding performance at the interface is high. As a result, it is effective to enhance the adhesiveness of the laminated body provided on the substrate of the angular velocity sensor.

[Best Mode for Carrying Out the Invention]

[0013]

(Preferred Embodiment 1)

Preferred embodiment 1 of the present invention is described below by referring to claim 1 to claim 4 of the present invention together with the accompanying drawings. Fig 1 is a perspective view of the angular velocity sensor in preferred embodiment 1 of the present invention, and Fig. 2 is a schematic diagram showing the configuration of its thin film laminated structure.

[0014]

In Fig. 1, the angular velocity sensor of preferred embodiment 1 includes substrate 4 shaped like a tuning fork having a pair of arms 2a, 2b extending in a specified direction (y-direction in Fig. 1), and joint section 3 for connecting this pair of arms 2a, 2b. As shown in Fig. 2, on each one of arms 2a, 2b of substrate 4, barrier layer 12, first adhesion layer 5, lower

electrode layer 6, orientation control layer 7, piezoelectric thin film 8, second adhesion layer 9, and upper electrode layer 10 are laminated sequentially to form laminated body 11. Laminated body 11 moves arms 2a, 2b to right and left when alternating-current voltages of mutually reverse phases are applied to driving electrode 10A on each upper electrode layer 10 of arms 2a, 2b.

[0015]

At this time, substrate 4 is made of single crystal silicon (Si). On the surface of this substrate 4, barrier layer 12 made of silicon oxide film (SiO_2) is formed. It can be formed easily by heating substrate 4 at 700°C or higher in the presence of oxygen or steam (thermally oxidizing). Barrier layer 12 made of SiO_2 is formed in a thickness of 20 nm to 300 nm.

[0016]

On the upper surface of this barrier layer 12, first adhesion layer 5 made of titanium (Ti) is provided, and in the upper part of first adhesion layer 5, lower electrode layer 6 made of platinum (Pt) containing Ti or titanium oxide (TiOx) is provided. Pt is high in conductivity, and excellent in stability in high-temperature oxidizing atmosphere. The film thickness of first adhesion layer 5 is more than 0 nm and less than 50 nm, and the thickness of lower electrode layer 6 is more than 0 nm and less than 500 nm.

[0017]

In the upper part of lower electrode 6, orientation control layer 7 is provided. At this time, orientation control layer 7 is mainly made of lead titanate ($PbTiO_3$), and contains lanthanum-magnesium-added lead titanate (PLMT) adding lanthanum (La) and magnesium (Mg). Orientation control

layer 7 controls (buffers) the lattice constant of the crystal of Pt for composing lower electrode layer 6, and the crystal of lead zirconate titanate (Pb (Zr, Ti) O_3: or PZT) for composing the piezoelectric thin film formed in the upper part of orientation control layer 7. The film thickness is less than 200 nm.

[0018]

In the upper part of orientation control layer 7, piezoelectric thin film 8 made of PZT is provided, and in the upper part of piezoelectric thin film 8, upper electrode layer 10 is provided by way of second adhesion layer 9. By applying an alternating-current voltage between lower electrode layer 6 and upper electrode layer 10 of driving electrode 10A, a piezoelectric displacement occurs in laminated body 11, and arms 2a, 2b vibrate to right and left. When an angular velocity is applied during this lateral vibration, distortion is applied, and a piezoelectric charge occurs in detecting electrode 10B, so that the magnitude of the distortion can be detected from outside. For both driving and detecting, the thickness of piezoelectric thin film 8 is 1000 nm to 4000 nm.

[0019]

Piezoelectric thin film 8 is made of PZT because it is effective to increase the piezoelectric displacement generated by laminated body 11. By using substrate 4 made of Si, the piezoelectric displacement generated by piezoelectric thin film 8 can be transmitted to the substrate efficiently, so that angular velocity sensor 1 of excellent piezoelectric characteristic may be realized.

[0020]

By such configuration, the piezoelectric characteristic of the piezoelectric thin film can be enhanced, and the angular velocity sensor may be reduced in size.

[0021]

More specifically, by forming barrier layer12 made of silicon oxide film (SiO_2) between substrate 4 and first adhesion layer 5, Si atoms of substrate 4 are prevented from diffusing into Pt of lower electrode layer 6 and PZT of orientation control layer 7 formed thereon, and piezoelectric thin film 8 formed further thereon, and degeneration can be suppressed. As a result, adverse effects are not applied on crystal orientation (001) surface oriented by priority on the upper surface of PZT of piezoelectric thin film 8, and hence the crystallinity of piezoelectric thin film 8 can be enhanced. As a result, the piezoelectric characteristic of piezoelectric thin film 8 can be enhanced, and piezoelectric thin film 8 of small size and high performance can be formed, so that angular velocity sensor 1 may be reduced in size.

[0022]

Further, the configuration of preferred embodiment 1 can enhance the adhesiveness of the laminated body. That is, substrate 4/barrier layer 12/first adhesion layer 5 are formed in $Si/SiO_2/Ti$, and SiO_2 and Ti are high in reducing properties, and the bonding performance at the interface is high. As a result, the present invention is effective to enhance the adhesiveness of laminated body 11 provided on substrate 4 of angular velocity sensor 1.

[0023]

Moreover, first adhesion layer 5 (Ti) and lower electrode layer 6 (alloy of Ti and Pt, or alloy of TiOx and Pt) are connected by metallic bonding. As

a result, the interface separation of layers from substrate 4 to lower electrode layer 6 can be suppressed, and the manufacturing yield is improved, and the reliability of angular velocity sensor 1 is enhanced. Similarly, second adhesion layer 9 is interposed between piezoelectric thin film 8 and upper electrode layer 10, and is effective to enhance the mutual thin film adhesiveness.

[0024]

As a result, the adhesiveness is enhanced in laminated body 11 provided on substrate 4 of angular velocity sensor 1.

[0025]

According to the laminated structure of preferred embodiment 1, the crystallinity of piezoelectric thin film 8 of angular velocity sensor 1 is further enhanced, and a greater piezoelectric displacement may be obtained.

[0026]

That is, in the tetragonal system PZT, the direction of polarization axis is (001) direction, and when the polarized PZT thin film is driven as a piezoelectric body, the characteristic (piezoelectric characteristic) is greatest when the direction of driving electric field and the direction of polarization are parallel to each other. That is, it is important that the direction of driving electric field is the (001) direction of crystal orientation. In order to apply the driving electric field in the (001) direction, it is required to form a PZT thin film having a priority orientation such that the (001) direction of piezoelectric thin film 8 may be parallel with an axis perpendicular to substrate 4, that is, the surface of piezoelectric thin film 8 may be the (001) surface.

[0027]

In order to form a PZT thin film of which thin film surface is the (001) surface, Pt containing Ti or TiOx is used in lower electrode layer 6, and further orientation control layer 7 is interposed between lower electrode layer 6 and piezoelectric thin film 8.

[0028]

First, the reason of using Pt containing Ti or TiOx in lower electrode layer 6 is explained. In high-temperature process (when forming by sputtering method explained later in preferred embodiment 2, if only argon gas is used, Ti of the surface portion of lower electrode layer 6 is not oxidized, but if a mixed gas of argon and oxygen is used, Ti is oxidized, and TiOx is formed), Pt is diffused in the crystal grain boundary of Ti, and Ti is diffused into the crystal grain boundary of Pt (mutual diffusion), and further Ti (TiOx) is diffused outside along the crystal grain boundary of Pt (external diffusion). By this external diffusion of Ti, formation of perovskite PZT thin film is promoted, and the surface of the PZT thin film is oriented by priority into the (001) surface.

[0029]

Next is explained the reason of interposing orientation control layer 7 between lower electrode layer 6 and piezoelectric thin film 7. Generally, in the crystal growth of layers when forming a thin film on substrate 4, it is a favorable condition for producing good crystals that the lattice constant of crystal of a certain layer matches with the lattice constant of crystal of a thin layer to be grown thereon (lattice matching). The lattice constant is a distance between mutual atoms for composing a single crystal. Each

substance has its own lattice constant, and the crystal of Pt and the crystal of PZT differ in the lattice constant (the lattice constant of PZT is 0.401 nm, and the lattice constant of Pt is 0.3921 nm).

[0030]

Accordingly, in order to control (buffer) the lattice mismatch, orientation control layer 7 is needed. In this preferred embodiment 1, PLMT is used as orientation control layer 7, and the lattice constant is controlled between the crystal of platinum for composing lower electrode layer 6 and the crystal of PZT for composing piezoelectric thin film 8.

[0031]

That is, if first adhesion layer 5 is oriented to have a (111) surface, orientation control layer 7 is easily oriented to have a (001) surface (in cubic crystals, a (100) surface is identical to a (001) surface). In other words, on the surface of first adhesion layer 5, Ti or TiOx scatters like islands, and orientation control layer 7 is formed by crystal growth at the upper side from the nucleus of Ti or TiOx scattering like islands. Hence, it is easily oriented to have a (100) surface or a (001) surface on Ti or TiOx.

[0032]

Since Ti or TiOx is contained in first adhesion layer 5, thus not protruding substantially from the surface of first adhesion layer 5 (if protruding, less than 2 nm), orientation control layer 7 is easily oriented to have the (100) surface or the (001) surface.

[0033]

On the other hand, first adhesion layer 5 is usually oriented to have a (111) surface when using substrate 4 being made of Si or the like, and a

region of orientation control layer 7 above the surface area of first adhesion layer 5 which does not contain Ti or TiOx is oriented to have other surface than the (100) surface or the (001) surface (for example, (111) surface orientation), and becomes an amorphous state. However, such region not oriented in the (100) surface or the (001) surface exits only in the vicinity of surface area (utmost about 20 nm from the surface) of orientation control layer 7 at the side of first adhesion layer 5. Therefore, the region oriented to have the (100) surface or the (001) surface on Ti or TiOx spreads along with its crystal growth, and the area of the region at a cross section perpendicular to the thickness direction of the layer increases from the first adhesion layer 5 side towards its opposite side (piezoelectric thin film 8 side), and hence the region not oriented to have the (100) surface or the (001) surface decreases, and when the thickness of orientation control layer 7 becomes about 20 nm, most of the region is oriented to have the (100) surface or the (001) surface.

[0034]

When piezoelectric thin film 8 is formed on this orientation control layer 7, orientation control layer 7 causes piezoelectric thin film 8 to be oriented to have a (001) surface (since a (100) surface is identical to a (001) surface in rhombohedral crystal, it includes a crystal orientation of a (100) surface of rhombohedral crystal). Such orientation control layer 7 allows piezoelectric thin film 8 to be made of a piezoelectric material having excellent piezoelectric characteristics, while orientation control layer 7 may be made of a material capable of enhancing the crystallinity or orientation property, and the degree of orientation of the (001) surface of piezoelectric

thin film 8 may be increased to 90% or more.

[0035]

The region of orientation control layer 7 not oriented to have the (100) surface or the (001) surface may exist not only in the surface area on the side of first adhesion layer 5, but also in the surface area on the side of piezoelectric thin film 8. Even in this case, as long as orientation control layer 7 has a thickness not smaller than 0.01 μm, most of the surface area of piezoelectric thin film 7 is oriented to have the (100) surface or the (001) surface, and the degree of orientation of the (001) surface of piezoelectric thin film 8 may be increased to 90% or more.

[0036]

According to this preferred embodiment 1, orientation control layer 7 is provided for enhancing the crystallinity and the crystal orientation to have the (001) surface, and therefore it may be made of an oxide derivative containing at least Pb and Ti, such as PLT containing La but not containing Zr, with the lead content in excess of its stoichiometrical amount. From the viewpoint of enhancement of crystallinity and crystal orientation of piezoelectric thin film 8, the amount of La should be more than 0 and less than 25 mol%, and the amount of lead should be more than 0, exceeding stoichiometrically, to less than 30 mol%. The material for composing orientation control layer 7 is not limited to this PLT, but may include PLZT having zirconium added to PLT, or PLT or PLZT additionally containing at least one of magnesium and manganese. The amount of zirconium is preferred to be 20 mol% or less, and when at least one of magnesium and manganese is added, the total amount should be more than 0 to less than 10

mol% (the amount of either one component may be zero).

[0037]

In this manner, lower electrode layer 6 is made of platinum containing Ti or TiOx, and orientation control layer 7 is interposed between lower electrode layer 6 and piezoelectric thin film 8, a PZT thin film of which thin film is oriented to have the (001) surface can be formed. Therefore, the crystallinity of the piezoelectric body is enhanced, and a large piezoelectric displacement is obtained.

[0038]

Summing up, by the laminated structure of angular velocity sensor 1 of this preferred embodiment 1, angular velocity sensor 1 is reduced in size. That is, a PZT thin film of which thin film is oriented to have the (001) surface can be formed, and the crystallinity of piezoelectric thin film 8 can be enhanced, so that piezoelectric thin film 8 of high piezoelectric characteristic in spite of small area is formed, and thereby angular velocity sensor 1 is reduced in size. There is another effect, that is, peeling at the interface between layers from substrate 4 to lower electrode layer 6 of the angular velocity sensor can be suppressed, and in particular the adhesiveness of substrate 4 and first adhesion layer 5 is enhanced, so that the reliability of angular velocity sensor 1 can be enhanced.

[0039]

An electronic device, such as an inkjet head, including a piezoelectric device other than an angular velocity sensor may include a vibration layer made of SiO_2 on a substrate of Si (a pressure chamber substrate in the inkjet head), but it is completely different in application and action from barrier

layer 12 made of SiO_2 in this preferred embodiment. That is, the vibration layer of the inkjet head vibrates for discharging the ink collected in the pressure chamber substrate out of the pressure chamber, and a certain thickness is required (about 0.5 to 10 μm).

[0040]

On the other hand, barrier layer 12 of this preferred embodiment 1 is provided for increasing the adhesiveness of layers and increasing the crystallinity of piezoelectric thin film 8, if its thickness is increased to about the extent of the vibration layer of the inkjet, adverse effects are given to the angular velocity sensor. That is, Si and SiO_2 differ in the Young's modulus. Therefore, if the thickness is excessive in the barrier layer formed of SiO_2 different in Young's modulus from Si, when arms 2a, 2b of the angular velocity sensor vibrate, adverse effects are given to the Young's modulus of the Si substrate, and distortion is generated in vibration of arms 2a and 2b. Hence, in the electronic device using a piezoelectric element such as inkjet head, the vibration layer of SiO_2 formed on the Si substrate is radically different in application and action from barrier layer 12 formed of SiO_2 in this preferred embodiment 1.

[0041]

(Preferred Embodiment 2)

Preferred embodiment 2 of the present invention is described below by referring to claim 5 to claim 9 of the present invention.

[0042]

Preferred embodiment 2 relates to a method of manufacturing laminated body 11 by laminating arms 2a, 2b (see Fig. 1) of the angular

velocity sensor of preferred embodiment 1. That is, this is a manufacturing method of angular velocity sensor 1, in which, first, the surface of substrate 4 made of single crystal silicon is oxidized to form barrier layer 12, then first adhesion layer 5 made of at least titanium is formed on this barrier layer 12 by sputtering method, consequently lower electrode layer 6 made of platinum containing at least titanium or titanium oxide is formed on this first adhesion layer 5 by sputtering method, orientation control layer 7 is formed on this lower electrode layer 6 by sputtering method, and then piezoelectric thin film 8 is formed on orientation control layer 7 by sputtering method, second adhesion layer 9 is formed on this piezoelectric thin film8 by sputtering method or vacuum deposition method, and finally upper electrode layer 10 is formed on this second adhesion layer 9 by sputtering method or vacuum deposition method. At this time, orientation control layer 7 is made of an oxide derivative containing at least Pb and Ti, for example, PLMT. Piezoelectric thin film 8 is made of PZT.

[0043]

As a result, as compared with the method of chemical vapor phase deposition, laminated body 11 as set forth in claim 1 to claim 4 can be manufactured easily. At this time, the method of forming barrier layer 12 by silicon oxide film by oxidizing the single crystal silicon substrate is preferred to be a thermal oxidation process because it is easier. Not limited, however, to the thermal oxidation process, it may be realized by sputtering method, thermal CVD method, plasma CVD method, sol-gel method, and others.

[Industrial Applicability]

[0044]

By using the laminated structure of the angular velocity sensor of the present invention, a piezoelectric thin film of high piezoelectric characteristic can be formed in a small area, and it is very effective for reducing the size of a piezoelectric electronic device using piezoelectric elements, especially an angular velocity sensor.

[Brief Description of the Drawings]

[0045]

Fig. 1 is a perspective view of an angular velocity sensor in preferred embodiment 1 of the present invention.

Fig. 2 is a schematic diagram showing a thin film laminated structure of the same.

Fig. 3 is a schematic diagram showing a thin film laminated structure of a conventional angular velocity sensor.

Fig. 4 is a schematic diagram showing the thin film laminated structure.

[Description of the Reference Numerals and Signs]

[0046]

1 Angular velocity sensor

2a, 2b Arms

3 Joint section

4 Substrate

5 First adhesion layer

6 Lower electrode layer

7 Orientation control layer

8	Piezoelectric thin film
9	Second adhesion layer
10	Upper electrode layer
11	Laminated body
12	Barrier layer

[Name of the Document] Abstract

[Abstract]

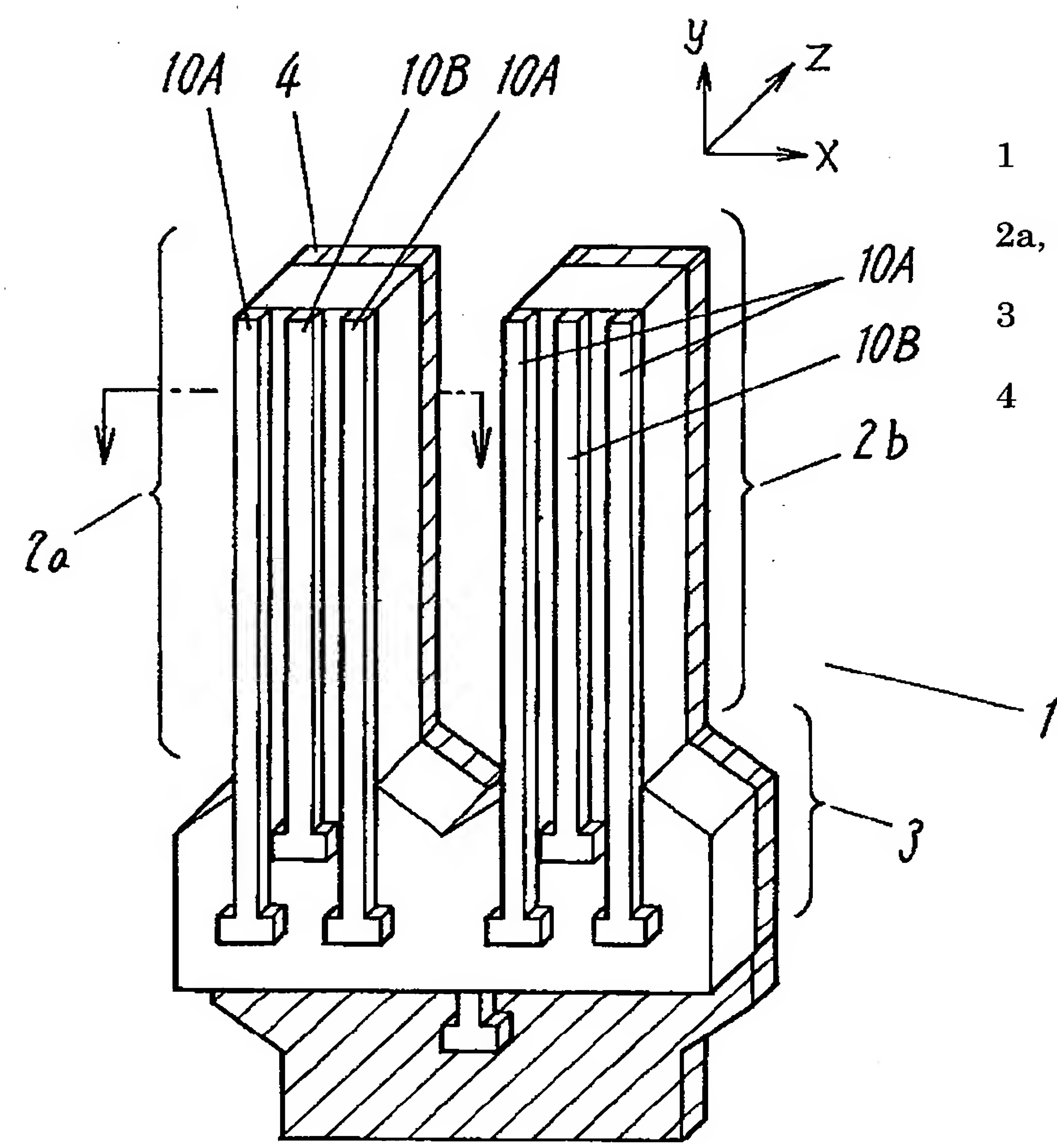
[Object] It is an object of the present invention to realize reduction of size of piezoelectric device and angular velocity sensor.

[Means to Solve the Problems] Substrate 4 is made of single crystal silicon, barrier layer 12 is made of a silicon oxide film, first adhesion layer 5 containing at least titanium, and lower electrode layer 6 is made of platinum containing at least titanium or titanium oxide, and thereby angular velocity sensor 1 is composed. As a result, angular velocity sensor 1 is reduced in size. That is, in spite of a small surface area, a piezoelectric thin film of excellent piezoelectric characteristic can be formed, and angular velocity sensor 1 is reduced in size.

[Selected Drawing] Fig. 2

[Name of the Document] Drawing

[Fig. 1]



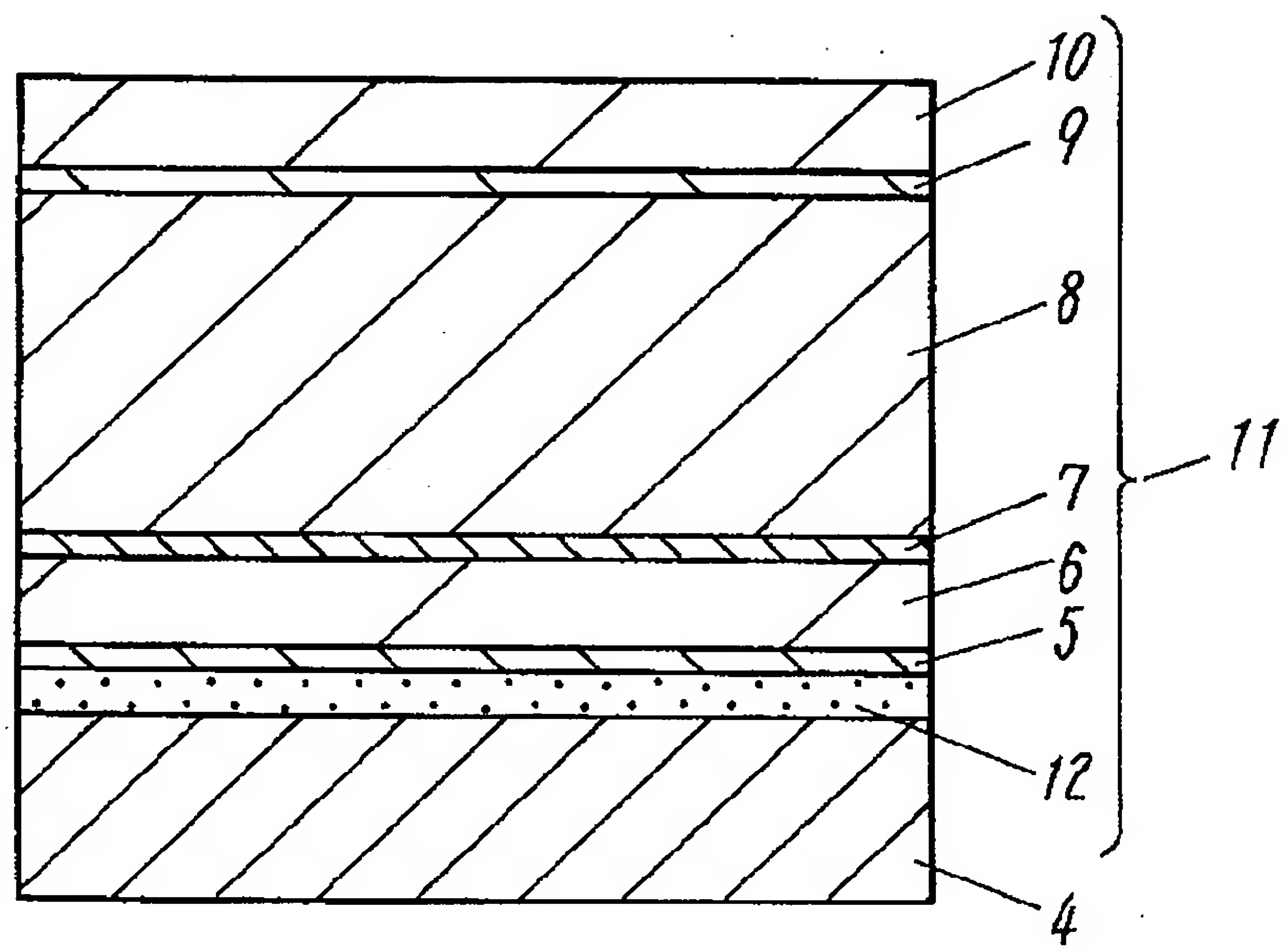
1 Angular velocity sensor

2a, 2b Arms

3 Joint section

4 Substrate

[Fig. 2]



4 Substrate

5 First adhesion layer

6 Lower electrode layer

7 Orientation control layer

8 Piezoelectric thin film

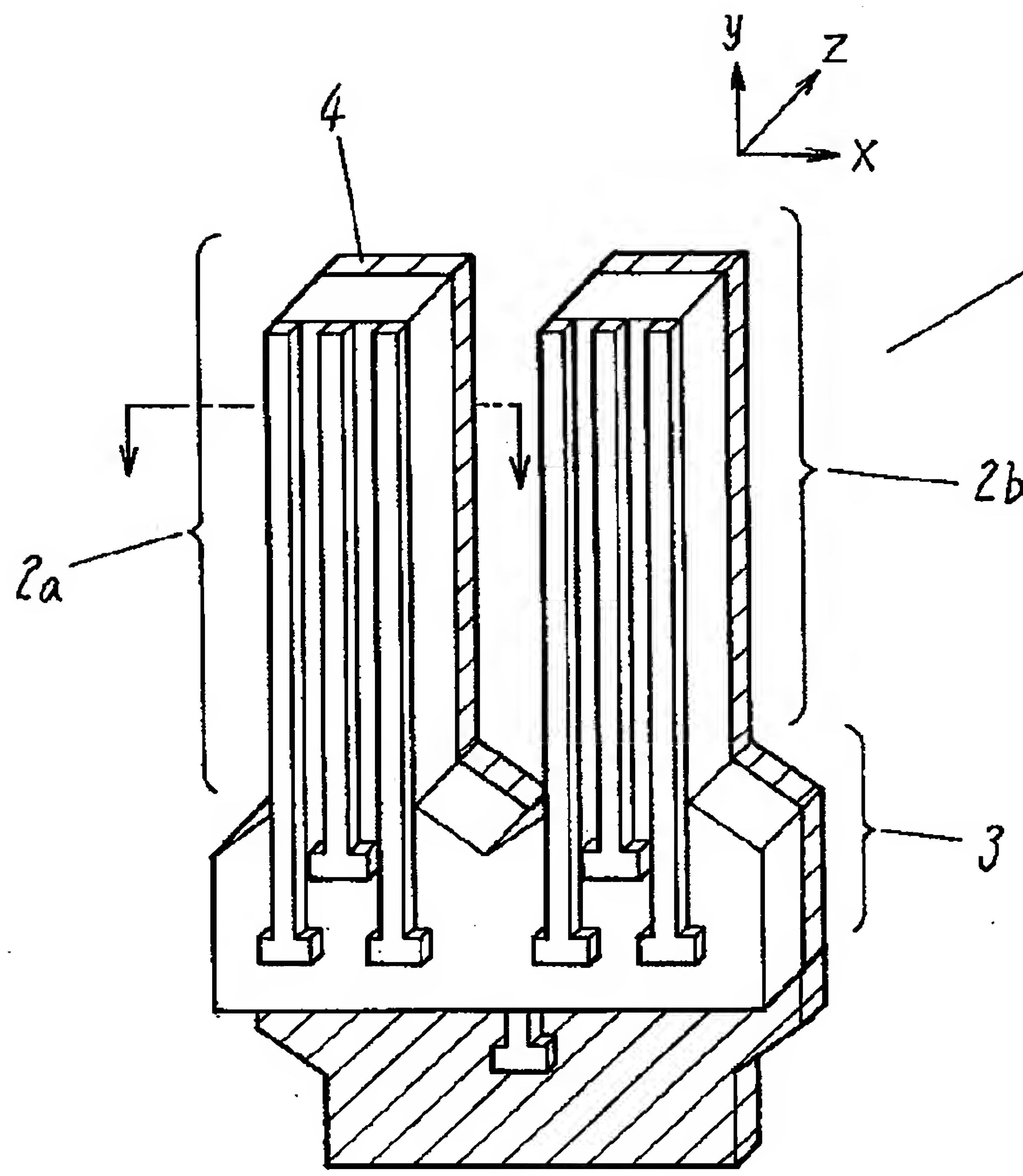
9 Second adhesion layer

10 Upper electrode layer

11 Laminated body

12 Barrier layer

[Fig. 3]



[Fig. 4]